Emissions Trading in Santiago, Chile:

A Review of the Emission Offset Program of Supreme Decree N^{o} 4

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Abstract

Santiago, Chile was subject to serious air quality problems in the late 1980s and early 1990s as a result of increased industrial and transportation emissions. In an effort to improve air quality, the government implemented a number of policies including an emission trading program to reduce and cap emissions of particulate matter smaller than 10 microns (PM10) from stationary sources. The emission trading program was viewed by many as a way to provide industry with flexibility to develop source-specific approaches to meet the reduction target at a lower cost and to reduce government administrative requirements.

The environmental objective of the program, to reduce PM10 emissions from stationary sources by 50%, was met by 1998. However, some academics, industry groups, and government officials have questioned the efficiency and effectiveness of the program, citing obstacles such as frequent rule changes, a lengthy and uncertain transaction approval process, and lack of market activity, which discourage trading and do not allow industry to take full advantage of cost-saving opportunities provided by the emission trading program. As an environmental program, it should be judged first and foremost on its achievement of the environmental goal. Developing the market is secondary, but it can make achieving the environmental objective more cost effective.

This paper reviews the program and highlights design alternatives for future emission trading programs in Santiago that may yield positive environmental benefits at lower cost.

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1 The author is a Senior Policy Analyst with the U.S. Environmental Protection Agency. The views expressed in this paper are those of the author and do not necessarily reflect the views of the U.S. Environmental Protection Agency.

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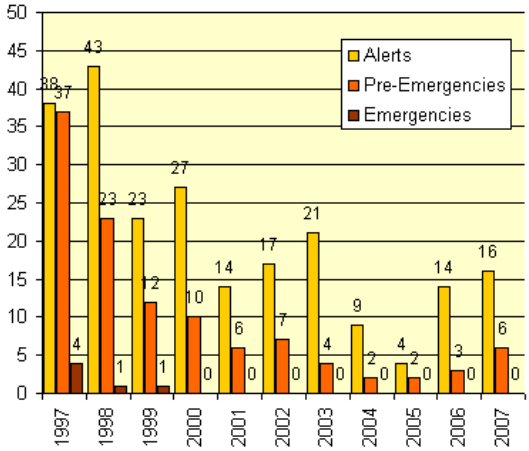
Santiago Air Quality & Emission Control Policies

Figure 1: Santiago Metropolitan Region

The Santiago Metropolitan Region (see figure 1) faces significant air quality challenges. Situated between the Andes and Cordillera de la Costa mountain ranges, the region experiences a persistent temperature inversion that is especially acute during the winter months; occasionally as low as three hundred meters. The temperature inversion and lack of wind cause emissions from local factories, power stations, and mobile sources to build up in the atmosphere. As a result, the city often exceeded ambient air quality standards for total suspended particulates (TSP) and particulate matter smaller than 10 microns (PM10). In 1990, the year of the first air quality plan for Santiago[3], the city exceeded the PM10 standard 95 days of the year (CONAMA, 2003). The government formally acknowledged the air quality problems in 1996, declaring the Santiago Metropolitan Region a non-attainment area for ozone (O_3), PM10, TSP, and carbon monoxide (CO). The area was also declared a latent area[4] for nitrogen dioxide (NO_2). The declaration prompted the Environment Commission (CONAMA) to develop an Air Pollution Prevention and Clean-up Plan (PPDA).

The key objectives of the PPDA were to reduce risks to human health from exposure to pollution; eliminate episodes of high PM10 concentrations; reduce concentrations of particulate matter smaller than 2.5 microns (PM2.5), which has greater human health consequences; reverse increases in concentrations O_3, PM10, TSP, CO, and NO_2; avoid generation of NO_X in saturated and latent areas; and meet ambient air quality standards (CONAMA, 1998).

Figure 2: Santiago Air Quality Episodes



Source: Fernandez, 2007

In addition to the policies outlined in the PPDA, the Metropolitan Environmental Health Service (SESMA) of the Ministry of Health implemented Supreme Decree Number 32 in 1990. The Decree established a program to reduce emissions during predicted severe air quality episodes. On days when the average daily ambient levels of PM10 are predicted to reach emergency levels (greater than 330

[3] The Special Commission for Decontamination of the Metropolitan Region (CEDRM) developed Santiago's first air quality plan in 1990. The plan recommended many actions that are still in place today, such as inspection programs for stationary and mobile sources.

[4] Areas are designated as "latent" if pollutant concentrations are between 80% and 100% of the relevant standard.

µg/m^3), the largest stationary sources that, in aggregate, are responsible for 50% of stationary source emissions must cease operation for a 24-hour period (beginning at 11:00PM the day before the predicted high concentration.) When the average daily ambient levels of PM10 are predicted to reach pre-emergency levels (240 µg/m^3 to 330 µg/m^3), the stationary sources responsible for the top 30% of emissions must cease operation for a 24-hour period. Between 1997 and 2005, the number of pre-emergency episodes dropped from 37 to two and emergency episodes declined from four to zero. Beginning in 2006, however, the trend reversed and the number of pre-emergency episodes started increasing (see Figure 2).

The Emission Trading Policy

In 1992, the Ministry of Health issued Supreme Decree Number 4 to control PM10 emissions from stationary sources in the Santiago Metropolitan Region. The Decree included three key provisions for stationary combustion sources (e.g., industrial and commercial boilers, industrial ovens, power plants) with a rated exhaust gas flow rate greater than 1,000 m^3/hour:

1. A maximum emission concentration standard;
2. A cap on total daily potential emissions from point sources; and
3. An emission trading program.

The maximum PM10 concentration for exhaust gases was set at 112 mg/m^3 – the level at which visible smoke appears (Borregaard, et al, 2001). However, as with any concentration standard, sources can meet the standard by diluting the exhaust gases without making real reductions. To ensure that PM10 emissions were reduced, the Decree included a cap on daily emissions with the flexibility to meet that cap through an emission trading program. Under the emission trading program, existing sources were allocated a specific quantity of daily emission permits (DEPs) based on potential emissions. Each DEP is an authorization to emit up to one kilogram of PM10 per day in perpetuity. New sources and expansions to existing sources placed in operation after March 2, 1992 or registered with SESMA after December 31, 1997 did not receive DEPs. These new and expanded sources had to purchase DEPs from existing sources to offset 25% of daily potential emissions by 1994, 50% by 1995, 75% by 1996, and 100% by 1997 (OECD, 2005).

SESMA used the following formula to allocate DEPs to the approximately 600 existing sources (Ministerio de Salud, 1992):

$$DEP\ (kg/day) = F_0\ (m^3/hour)\ X\ C_0\ (mg/m^3)\ X\ 10^{-6}(kg/mg)\ X\ 24\ (hours/day)$$

Where:

DEP is the number of daily emission permits granted to the source

F_0 is the maximum flow rate of exhaust gas determined by a combustion unit's rated size

C_0 is a default concentration of PM10 in the exhaust gas

During the first phase of the program (1994 – 1999), the default concentration of PM10 in exhaust gas (C_0 in the above formula) was 56 mg/m^3. This level was chosen because it was half the maximum concentration limit of 112 mg/m^3. For the period 2000 through 2004, the default

concentration (C_0) for the allocation formula was reduced to 50mg/m^3. Beginning in 2005, the default concentration (C_0) was further reduced to 32 mg/m^3 (O'Ryan, 2002).

To assess compliance with Supreme Decree Number 4, stationary sources are required to measure and certify their emissions concentration once per year. The measurement must be conducted by Measurement and Analysis Laboratories authorized by SESMA (CONAMA, 2004b). There are also random inspections throughout the year to verify the emissions concentration and ensure the source is using the specified fuel(s) on which the emission concentration is based. The source's daily potential emissions are calculated by multiplying the measured emission concentration and the source's maximum potential daily flow rate of exhaust gas (assuming 24 hours of operation.) This result is compared to the number of DEPs the source holds. If the source holds sufficient DEPs, it is in compliance with the emissions trading program. In addition to the requirement to hold sufficient DEPs, the source's measured emission concentration must be below the maximum PM10 concentration established by the Decree – 112 mg/m^3 – regardless of the number of DEPs a source holds.

Because emissions are calculated using the maximum potential flow of exhaust gases, the options available to sources to "reduce" emissions are limited to reducing the maximum potential flow or the pollutant concentration in the exhaust gases. This can be accomplished by switching to cleaner-burning fuels or installing pollution controls. There are other options for reducing emissions that may not affect concentration, and therefore are not reflected in the calculation. These include measures that would reduce actual daily flow of exhaust gases but not potential daily flow of exhaust gases, such as reducing utilization and improving combustion efficiency to burn less fuel.

A source that reduces its daily potential emissions to a level below the number of DEPs it holds can sell the surplus amount. However, because the DEPs are an authorization to emit up to one kilogram of PM10 per day in perpetuity, a trade results in a permanent reduction in the transferor's DEPs and a corresponding permanent increase in the recipient's DEPs[5].

Since its introduction, the emission trading program has gone through a number of changes. In 1995, industrial processes were excluded from the program because SESMA – the agency charged with operating the emission trading program – determined it was too difficult to estimate industrial process emissions. In addition to the changes to the default concentrations for the allocation formula mentioned earlier, SESMA increased the offset ratio for new and expanded sources from one DEP for each kilogram of potential daily emissions to 1.2 DEPs per kilogram in 1998. In 2001, the offset ratio was further increased to 1.5 DEPs per kilogram (O'Ryan, 2002.)

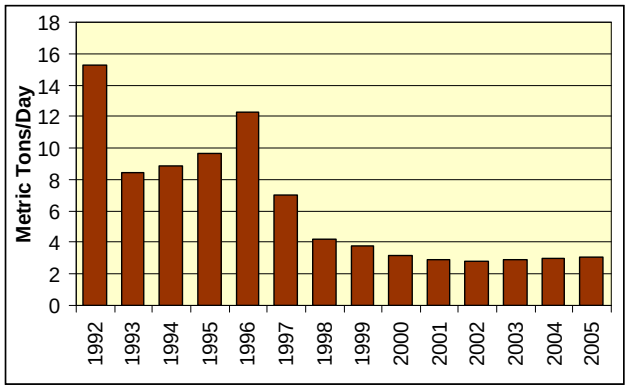
[5] By contrast, the U.S. Acid Rain Program (SO_2), U.S. NO_X Budget Trading Program, Regional Clean Air Incentives Market (RECLAIM) Program (SO_2 and NO_X), and the EU Emission Trading Scheme (CO_2) use an allowance "vintage" – the first compliance period in which the allowance can be used to compensate for emissions. Because new tradable allowances are issued for each compliance period, a source with surplus allowances can sell those allowances for a single vintage to another source. The sale will not alter the allocation for the following compliance period.

Emission Trading Program Results

Following full implementation of the emission trading program in 1997, air quality in the Santiago Metropolitan Region has improved significantly (see Figure 3). Between 1992 and 2005, PM10 concentrations decreased by almost 40% and potential PM10 emissions decreased by almost 80% from 15.3 tons per day to 3.1 tons per day (see Figure 4). Stationary sources had reduced potential PM10 emissions significantly more than required to meet the emission reduction goal of Supreme Decree Number 4.

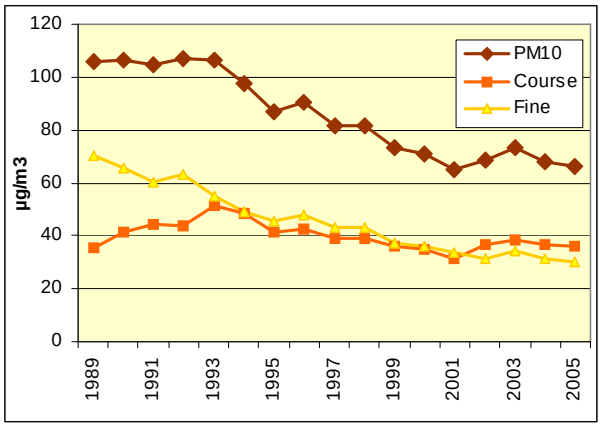
There were a number of factors that influenced the attainment of the emission reduction goal, but perhaps the most influential were the availability of natural gas and the desire to be removed from the list of highest polluters that must shutdown during air quality emergency and pre-emergency episodes. In 1997, natural gas from Argentina became widely available. It was convenient and cost-effective for sources to switch to this new, cheaper fuel. In addition to potential cost savings, switching to cleaner fuels enabled the highest emitting sources to get off the list of most polluting industries; meaning they did not have to cease operation during emergency and pre-emergency episodes. By July 1999, more than 30% of sources in the program had switched to natural gas (Montero, et al, 2000.) However, in 2004, Argentina announced that it would restrict natural gas exports to neighboring countries to prevent a domestic energy crisis. Chile imported more than 90% of its natural gas from Argentina and depends on it to operate industry and generate electricity. The reduced natural gas supplies from Argentina forced industrial sources and electricity generators to switch to alternative, more costly fuels with higher PM10 emissions. Chile has been actively seeking out alternative sources of natural gas and has started construction of a Liquefied Natural Gas (LNG) terminal to lessen the reliance on Argentinean natural gas.

Figure 4: Santiago Average Daily PM10 Emissions



Source: CONAMA, 2007

Figure 3: Santiago Annual Average PM10 Concentrations – Course & Fine

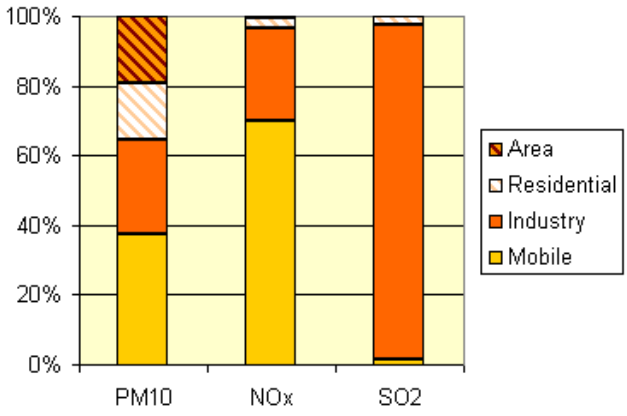


Source: 1989 – 2002: Alliende Correa, 2003;
2003 – 2005: SESMA, 2007b

While stationary sources have met the emission reduction goal, the emission trading market has seen very little activity since the program began. During the first three years of the program, no transactions were approved while the regulatory authority was developing comprehensive source and emission inventories (Montero, et al, 2000). Following completion of the inventory, there was little market activity. Many of the trades that did occur were between facilities owned by the same firm. Some possible reasons for the limited number of transactions include:

- A small number of companies hold a majority of allowances. The top five firms own almost one-third of all DEPs (Montero, et al, 2000.)
- Emission reduction strategies are limited to fuel switching and equipment changes because the program is based on daily potential emissions, not actual emissions. Consequently, the cost of reducing potential emissions (i.e., switching to natural gas) is similar across many sources. This limits the potential cost savings from the emission trading program.
- Only stationary combustion sources, which were responsible for 7% of total PM10 emissions in 2000, are included in the program. The inclusion of other source types, such as process emission sources, would increase the size of the market, bring a larger portion of total emissions under the cap (see Figure 5), and may increase opportunities for economic efficiency by creating more heterogeneity of control costs.

Figure 5: Year 2000 Emissions by Source Type



Source: CONAMA, 2003

- The trading procedures are not clearly defined; there are few market intermediaries, such as brokers, to help match buyers and sellers; and there is little information available about market prices. As a result, administrative transaction and information costs are high. In an effort to find potential buyers, parties have started posting advertisements in newspapers offering DEPs for sale.
- The approval process for transactions is lengthy and uncertain. The Decree allowed SESMA up to 30 days to review and approve transactions. However, it often takes three to ten months for SESMA to review and approve transactions (O'Ryan, 2002.) In contrast, cap and trade programs in the U.S. and Europe do not require regulatory approval for trades. In the U.S. Acid Rain Program, for example, 98 percent of allowance transfers in 2006 were recorded online with no regulator involvement. This was possible because the emissions cap provides certainty that reductions are made and maintained, local air quality rules restrict the ability of firms to significantly increase emissions in a local area, and computerized tracking systems enable account holders to manage their allowances directly.
- Since the market is not active, many sources are reluctant to trade because they are uncertain of their ability to buy back allowances if they are needed for future expansion (Montero, et al., 2000) or if the concentration rates used for the allocations are changed, as they were in 2000 and 2005. Because DEPs are traded in perpetuity, not for a single day, season, or year, any source transferring DEPs will see a permanent reduction in their allowable potential emissions[6].

[6] Some sources have started to experiment with "renting" DEPs for a single year. This was not addressed in the program rules and SESMA has not stopped this practice.

- Frequent rule changes can also influence compliance decisions and influence the market. Over the first few years of the program, a number of rules were changed with little lead time for affected sources to adjust to the changes. In 1995, industrial processes were exempted from the compliance requirements. In 2000 and 2005, the default concentration rate (C_0) used in the allocation formula was changed from 56 mg/m^3 to 50 mg/m^3 and 32 mg/m^3, respectively. And in 1998 and 2001, the offset ratio for new sources was changed from 100% to 120% and 150%, respectively.

Although the program has encountered some challenges, it was very effective in at least three ways. First, it improved the inventory of sources and potential emissions. DEPs were grandfathered to sources in existence at the time the Decree was promulgated, so many new sources that were not known to exist at the time and sources that were believed to be closed came forward to claim their DEPs (Montero, et al, 2000; O'Ryan, 2002). Similar situations occurred in both Slovakia and the U.S. where sources came forward to correct annual emission reports because the data were used to allocate allowances (USEPA, 2003). Other policy approaches may not have caused sources to come forward to report emissions. Second, the emission trading program has encouraged sources to internalize the cost of pollution and explore innovative ways to reduce emissions. Third, the emission reduction requirements likely influenced a number of sources to switch to natural gas as a cost-effective approach to meeting the reduction targets.

Future Direction of Emission Control Policies in Chile

CONAMA and other relevant authorities in Santiago plan to update the Pollution Prevention Plan (PPDA) for Santiago in 2008. The development of the new plan provides the government with an opportunity to improve the air quality policies by enhancing the emission trading program. Some of the key updates may include (CONAMA, 2004b):

- *Establishing goals and emission trading programs for NO_X emissions from stationary sources*. The PPDA includes a goal to reduce NO_X emissions from boilers and industrial processes 33% below 1997 levels by May 2007 and 50% below by May 2010. To provide industry with greater flexibility to meet the target, the PPDA envisions a NO_X emission trading program.
- *Improving the emission trading program for PM10 and establishing a goal to reduce PM10 from industrial processes to 50% below 1997 levels by May 2007*. Industrial processes may be added to the existing PM10 emission trading program.
- *Requiring manufacturers and/or importers of residential heating equipment (e.g., wood stoves) to offset TSP emissions generated by their equipment*. It is not clear if these manufacturers/importers will be included in the PM10 emission trading program or if they must find offsets outside of the program (i.e., investing in emission reduction projects.)
- *Implementing a major restructuring of the public transportation sector in February 2007*. The program, called TranSantiago, significantly reduced the number of buses in the Santiago Metropolitan Region; restricted older, dirtier bus engine technologies from the city center; expanded the subway system; and integrated bus and subway lines.[7] Emissions from the bus network will be controlled through technology mandates and incentives, such as longer concessions for cleaner technologies. There is also the

[7] The TranSantiago program has encountered some implementation difficulties in its early stages. For more information about TranSantiago, see the official website: http://www.transantiago.cl

possibility that the government may introduce an emission trading program to offer more flexibility in how the emission reduction targets are met.

In addition to the activities in the PPDA, the National Congress of Chile has been discussing the adoption of a law that would provide CONAMA and SESMA the authority to establish cap-and-trade[8] programs for a number of air pollutants in the Santiago Metropolitan Region. The proposed law has been in committee since 2002 and its passage is unlikely in the short term.

Design Alternatives for the PM10 Emission Trading Program

The Chilean Government and the Santiago Metropolitan Regional Government are regional leaders in the use of market-based policies to improve environmental conditions and resource use[9]. The PM10 emission trading program and other policies implemented in the PPDA have led to significant reductions in PM10 concentrations and air quality episodes. That said, the existing PM10 emission trading program is complex, creates uncertainty for the regulator and industry, and lacks a well-running market. International experience, and the U.S. experience in particular, has shown that emission trading programs can lead to significant emission reductions at a lower cost than conventional command-and-control regulations, but careful design and government oversight are critical to the program's success.

The Santiago PM10 emission trading program has many of the fundamental elements of an effective, credible program. Based on existing experience, the following enhancements could improve the results and credibility of the program:

1. *Establish clear, simple rules for the emission trading program*. Markets function better when the rules are simple and easily understood by the regulator and industry. Clear, simple rules are also easier to enforce. In contrast, complexity often requires more information collection, debate, and decisions. Complexity can create uncertainty and unnecessary burden that may lead to delays, missed emission reduction and cost-savings opportunities, and ultimately higher costs (USEPA, 2003; Napolitano et al, 2007.) The rules for determining which sources are affected by the program (applicability), how DEPs are distributed to sources (allocation), procedures for transferring allowances, protocols for measuring and verifying emissions, and penalties for noncompliance may provide opportunities to clarify and simplify the rules.

2. *Create transparent procedures for changing the program rules and provide sufficient lead time for industry to adapt to any changes*. Predictability and consistency are important principles for an effective emission trading program. These principles help create the right circumstances to encourage innovation and reduce costs. This does not mean, however, that rules cannot change in response to new information. The program framework must articulate the possibility for change and provide a clear explanation of the process for changing the rules and the conditions under which the rules can change (USEPA, 2003). Stakeholders should be consulted to develop a process that is clear, fair, and open. Once the process is established, changes should be minimized and modifications that are adopted should provide industry with sufficient time to modify their compliance strategies to reflect the program changes. Working with industry in a preventative and collaborative manner can improve compliance by encouraging sources to find and resolve problems early, save

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8 For a description of the different forms of emission trading programs, including cap-and-trade programs, see "Tools of the Trade: A Guide to Designing and Operating a Cap and Trade Program for Pollution Control" <http://www.epa.gov/airmarkets/resource/docs/tools.pdf>

9 In addition to the PM10 emission trading program, Chile has a well-regarded water rights trading program.

resources in the long term, and improve the relationship between government and industry (Schakenbach, et al, 2006.)

3. *Identify opportunities to introduce other source types, including stationary process emitters in the program*. Process emissions represented 17% of Santiago's total PM10 emissions in 2000. Restricting the emission trading program to combustion emissions, approximately seven percent of total PM10 emissions (CONAMA, 2003), limits the impact of the program, the number of potential buyers and sellers, and the opportunities for cost savings. If process emissions, and possibly other emission sources, were included in the program, a greater share of total PM10 emissions would come under control of the program's emissions cap, providing greater environmental benefits. It may also introduce greater heterogeneity of control costs, increasing the potential for economic efficiency by allowing high-abatement-cost sources to purchase DEPs from low-abatement-cost sources. Including process emissions would also increase the size of the market, which could increase opportunities for trades and reduce transaction costs. However, the ability to accurately estimate potential emissions is important to the credibility of the DEPs and the program.

4. *Base compliance on actual emissions*. When the emission trading program was created, monitoring and enforcement capabilities were limited and institutions were weak and underfunded (O'Ryan, 2002.) As a result, the system had to be simple to operate and costs for both government and industry had to be kept low. However, the current approach of measuring potential daily emissions does not provide a clear picture of the effect on actual emissions and it discourages firms from pursuing emission reduction approaches that may not affect the emission concentration rate in the exhaust gas. Establishing clear, consistent protocols to measure and/or estimate actual emissions will encourage sources to reduce their total emissions, not simply the emission concentration[10]. It is not necessary to select the most accurate measurement approach for all sources, but less accurate emission measurement or estimation methodologies should be conservative (i.e., tend to overestimate emissions) in order to ensure that all emissions are accounted for. This ensures that emissions are not underreported, provides better environmental certainty, and creates an incentive for sources to move to more accurate measurement approaches if it is in their best interest. One alternative approach to calculating PM10 emissions is to use gas flow and an emissions correlation curve. Flow can be measured directly with a gas flow meter or calculated indirectly based on fuel combustion. If the latter approach is used, the calculation should be conservative to overcome uncertainties in the formula. To develop the correlation curve, each source would measure PM10 concentrations at three or four representative loads with the fuel(s) that may be burned at the facility. Using the correlation curve, the source and/or regulators can find the appropriate concentration level based on the load level and multiply it by the measured or calculated flow. Instead of once-annual calculations, this approach would allow daily or even hourly emission calculations.

5. *Change the DEPs to AEPs – Annual Emission Permits*. Under a program with daily emission limits, each source must hold DEPs greater than or equal to its highest emissions for a single day of the year. This approach can restrict a company's ability to move production among its facilities because no facility is able to exceed its number of DEPs. For example, a company with two similar facilities would not be able to shift production between plants if it would cause one of the plants to exceed its DEP holdings even if the emissions for both facilities were below the combined DEP holdings. Transitioning to an annual emission permit

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[10] For additional information about principles for emission monitoring protocols, see "Fundamentals of Successful Monitoring, Reporting, and Verification Under a Cap-and-Trade Program" < http://www.epa.gov/airmarkets/cap-trade/docs/fundamentals.pdf >

gives sources temporal and geographic flexibility to determine when and where to make reductions. Local air quality is still protected against daily emissions increases by the maximum concentration limit of 112 mg/m^3.

6. *Assign a "vintage" year to AEPs and issue new AEPs for each compliance year*. The perpetual nature of DEPs in the existing PM10 emission trading program serves as a disincentive for sources to trade. Many sources appear reluctant to trade DEPs in perpetuity in the event that they may need them for future expansions or new facilities. By issuing AEPs for each compliance period, sources can transfer permits for a single compliance period without fear of the long-term consequences of a transaction. This will serve to increase the liquidity of the market while maintaining the environmental integrity of the program. Creating AEPs for each compliance year will require the government to consider a number of possible new rules, including: 1) whether unused AEPs can be banked for future use, 2) whether AEPs are allocated permanently or periodically updated to reflect new sources and economic and industrial changes, and 3) how many years of AEPs are distributed in advance[11] (i.e., allocating AEPs to sources in advance of the "vintage" period.)
7. *Create a seasonal AEP offset/compliance rate.* PM10 emissions have a greater impact on air quality during the winter months when thermal inversions are common. Therefore, the program should encourage greater emission reductions during the winter months. To accomplish this, SESMA could establish seasonal compliance rates. For example, during the summer months, the government might require a source to submit one AEP for compliance for each kilogram of PM10 emitted. During the winter months, however, the compliance requirement might increase to a higher number of AEPs for each kilogram of PM10 emitted. This would provide an economic incentive to further reduce emissions during the winter months. Alternatively, the government could create a year round program and a separate winter program. This latter approach would ensure that annual emissions declined and would establish a fixed cap for the winter months. This is similar to the approach for NO_X in the U.S. Clean Air Interestate Rule which establishes annual and summertime NO_X programs. Both approaches would require reporting of winter and summer emissions in order to assess compliance.
8. *Simplify transaction procedures and reviews.* The current review process for DEP transactions is lengthy and creates significant uncertainty for sources. SESMA could conduct an assessment of the review process and look for alternative ways to address any concerns about transfers. For example, if emission sources in a specific location have a greater effect on local air quality the government could establish different compliance ratios for the area[12]. Under this approach, sources in a zone with a greater impact on air quality might have to submit more AEPs for each kilogram of emissions than sources outside the critical zone.

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11 For additional information about allocations, including principles, options, and advantages/disadvantages of different allocation approaches, see "Tools of the Trade: A Guide to Designing and Operating a Cap and Trade Program for Pollution Control" <http://www.epa.gov/airmarkets/resource/docs/tools.pdf>

12 The U.S. Clean Air Interstate Rule (CAIR) establishes different compliance ratios for emission sources in the Eastern and Western U.S. Beginning in 2015, sources in the Eastern U.S. must submit 2.86 allowances per ton of SO_2 while sources in the Western U.S. are required to submit one allowance per ton of SO_2. See CAIR Federal Register Notice, pages 25258 - 25293 for more details <http://a257.g.akamaitech.net/7/257/2422/01jan20051800/edocket.access.gpo.gov/2005/pdf/05-5723.pdf>.

9. *Conduct an annual AEP auction to provide a price signal to the market and give new and expanded sources an opportunity to buy AEPs.* Transaction costs in the existing program are high because it is difficult and time consuming to find trading partners and there is little information available about the size and price of concluded transactions. A small auction would address both of these problems, providing new and expanding sources with an opportunity to purchase AEPs and setting a market price for potential buyers and sellers to use in developing their compliance strategy. Revenues from the auction can be used for program administration, including emission measurement and data management. The government-sponsored auction can also be an opportunity for potential AEP sellers to find a buyer. In the U.S. Acid Rain Program, for example, allowance holders can ask the Environmental Protection Agency to sell their allowances at the annual auction.
10. *Establish computerized tracking systems to manage emissions, AEPs, and compliance data*. Computerized tracking systems, sometimes referred to as registries, provide a number of administrative benefits, including the ability to handle large volumes of data; improve data accuracy, availability, consistency, and comparability; and reduce administrative time and costs (Schreifels, 2003.) Computerized tracking systems can provide capabilities for authorized source representatives to update information about their sources and accounts, transfer allowances, and certify compliance over the Internet through a secure website. These capabilities significantly reduce the administrative effort required to operate the emission trading program (Napolitano et al, 2007).
11. *Publish program results*. Transparency is important to a well-functioning emission trading program. Publishing the results of a program, including emissions, transactions, and compliance outcomes can serve as a strong incentive for sources to comply with the program requirements (aversion to bad publicity). Transparency also promotes confidence in the program and government institutions by demonstrating that the program is properly enforced.

Conclusions

The Santiago PM10 emission trading program was implemented with high expectations and has achieved its environmental goal, but some stakeholders believe the program has not lived up to its potential. As the use of emission trading programs is considered for NO_X and other emission source types, CONAMA and SESMA have a valuable opportunity to learn from the PM10 emission trading program's experience and identify opportunities to update the program.

It is important to remember that this is an environmental program and it should be judged first and foremost on its achievement of the environmental goal. Developing the market is secondary and should only serve to make the environmental objective more cost effective. Successful emissions trading programs around the globe have several elements in common. First, they have a strong emphasis on accountability – complete, accurate emission measurement; data transparency; and rigorous enforcement. Second, they are built on simple rules that promote accountability; environmental integrity; and an effective but minimal government role focused on verifying emissions data, tracking ownership of tradable permits, and enforcing program rules. These elements are critical to the success and credibility of an emission trading program. When these elements are in place, emission trading programs can offer industry the flexibility to develop custom emission reduction strategies. By offering this flexibility and internalizing the costs of pollution, the program unleashes the energy and creativity of industry to find solutions that can significantly reduce emissions at lower costs.

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